

1 THERMOPLASTIC DOOR SKINS AND METHOD OF MANUFACTURE THEREOF

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3 Background of the Invention

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5 The present invention relates to materials for forming
6 door skins for use in manufacturing doors and the process
7 for forming the door skins.

8 Doors are increasingly being manufactured from plastic
9 components. Typical door assemblies comprise a pair of
10 compression molded exterior skins, having wood grain
11 patterns on their outer surfaces, which are mounted on a
12 rectangular frame which separates and supports the skins in
13 spaced apart relationship. The hollow space between the
14 skins is filled with foam, such as a polyurethane foam.
15 These composite door assemblies resist rot or corrosion and
16 are generally better insulators than wood or metal doors.
17 Because of material costs and manufacturing efficiencies,
18 composite door assemblies are considerably less expensive to
19 manufacture than wood doors and can be designed to provide a
20 reasonable facsimile of a wood grain door.

21 The compression molding process utilized in
22 manufacturing currently available door assembly skins does
23 have limitations which effect the efficiency of the molding
24 process and place limitations on the design of the skins. A
25 typical compression molding process involves manually

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1 placing a first rectangular sheet of a thermosetting resin
2 within a lower mold half corresponding to the shape of the
3 outer surface of the door skin. A sheet of reinforcing
4 material, typically a fiberglass mat, is placed on top of
5 the first sheet of thermosetting resin and then a second
6 sheet of thermosetting resin is placed on top of the
7 fiberglass mat. An upper mold half is then advanced into
8 engagement with the lower mold half to compress the layered
9 materials therebetween and the mold is heated to cause the
10 layers of thermosetting resin to melt, disperse through or
11 bond with the reinforcing material and to conform to the
12 shape of the mold. Further compression and heating of the
13 mold and subsequent cooling thereof causes the thermosetting
14 material to set in the molded shape. After setting, the
15 thermosetting process generally cannot be reversed and any
16 finished material which is flawed, scrapped or otherwise
17 rejected must be disposed of typically in an expensive
18 controlled landfill.

19 In a simple compression molding process as described
20 above, the resulting molded structure including structural
21 elements molded therein must be of a relatively consistent
22 thickness. The addition of relatively thicker structural
23 elements in the door skin or the addition of structural
24 elements which require the displacement of a considerable
25 amount of molding material away from the face of the door

1 skin require the use of secondary molding steps to build up
2 the structural element. Such secondary molding steps
3 significantly add to the molding cost and the cost of the
4 finished product.

5 Thermoplastics can be reused and it is known that a
6 molded part of varying thickness can be produced in a closed
7 injection molding process. However, due to cost
8 considerations, a closed injection molding process is
9 generally impractical for the commercial production of door
10 skins.

11 There remains a need for improved door skin designs
12 which facilitate assembly of the door skins and reduce
13 manufacturing costs. Although others have discussed the
14 possibility of thermoplastic door skins, to applicant's
15 knowledge no one has successfully produced a thermoplastic
16 door skin. In particular, U.S. Patent No. 5,644,870
17 mentions that the door skins disclosed therein can be formed
18 from thermoplastic material, but the disclosure is not
19 enabling for use of thermoplastic materials.

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21 Summary of the Invention

22 The present invention comprises a composite door
23 assembly including door skins which are formed from
24 thermoplastic material. In a preferred embodiment, the
25 thermoplastic material used to form the door skin is a

1 polypropylene copolymer resin. Additives including
2 reinforcing glass fiber strands, fillers such as talc, a UV
3 stabilizer such as a benzotriazole and pigment are also
4 utilized in combination with the thermoplastic material.
5 The door skins are formed in a thermoplastic flow forming
6 process wherein the molten thermoplastic molding material
7 including additives flows from a flow controlled die onto a
8 lower mold half for the skin which is moving below the die.
9 The flow of molten molding material through the die is
10 controlled such that the amount of molding material laid
11 down in a particular area of the mold generally corresponds
12 to the desired thickness of the portion of the molded part
13 at that area. After the lower mold half is filled, it is
14 advanced to a press and an upper mold half is advanced into
15 engagement with the lower mold half to form the door skin
16 therebetween. After cooling, the mold halves are separated
17 and the molded skin is ejected.

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Brief Description of the Drawings

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3 Figure 1 is a front plan view of a door assembly.

4 Figure 2 is an enlarged and fragmentary cross-sectional
5 view taken along line 2-2 of Figure 1.

6 Figure 3 is an enlarged and fragmentary top plan view
7 of the door assembly as in Figure 1.

8 Figure 4 is an enlarged and fragmentary front plan view
9 of a rear skin of the door assembly.

10 Figure 5 is an enlarged and fragmentary front
11 perspective view of the rear skin of the door assembly.

12 Figure 6 is an enlarged and fragmentary cross-sectional
13 view taken along line 6-6 of Figure 1.

14 Figure 7 is an exploded perspective view of the door
15 assembly without a layer of foam injected between the front
16 and rear skins.

17 Figure 8 is a schematic diagram of a thermoplastic flow
18 forming process by which skins of the door assembly are
19 produced.

1 Detailed Description of the Invention

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3 As required, detailed embodiments of the present
4 invention are disclosed herein; however, it is to be
5 understood that the disclosed embodiments are merely
6 exemplary of the invention, which may be embodied in various
7 forms. Therefore, specific structural, compositional and
8 functional details disclosed herein are not to be
9 interpreted as limiting, but merely as a basis for the
10 claims and as a representative basis for teaching one
11 skilled in the art to variously employ the present invention
12 in virtually any appropriately detailed structure,
13 composition or process.

14 Referring to the drawings in more detail, the reference
15 numeral 1 refers to a door assembly. As generally shown in
16 Figures 1 through 6, the door assembly 1 comprises a pair of
17 opposed or front and rear door panels or skins 5 and 6. The
18 door assembly 1 is an example of the type in which the
19 components, including skins 5 and 6 may be formed using
20 thermoplastic material and formed using a thermoplastic flow
21 forming process.

22 Door Skin Assembly Construction

23 The front and rear skins 5 and 6 are connected together
24 by connectors 8, 9 and 10 and mounted on frame 12. Frame 12
25 comprises first and second stiles 13 and 14, top rail 15 and

1 bottom rail 16. The interior space 19 between the skins 5
2 and 6 is filled with a polyurethane foam 20 which is
3 injected therein after assembly of the skins 5 and 6, with
4 connectors 8, 9 and 10 on the stiles 13 and 14 and top rail
5 15 of frame 12. The bottom rail 16 is inserted and secured
6 between lower ends of stiles 13 and 14 after injection of
7 polyurethane foam 20 within the interior space 19.

8 Skins 5 and 6 are identical in construction. An outer
9 or exterior surface 25 of each skin 5 and 6 is textured
10 during the molding process to imitate a wood grain texture.
11 A tongue is formed on an inner surface 27 of each skin 5 and
12 6 and extends around the outer periphery of the sides and
13 the top thereof. In particular, a first side tongue 30
14 extends along a first side edge 31 of each of the skins 5
15 and 6, a second side tongue 32 extends along a second side
16 edge 33 of each of the skins 5 and 6, and a top tongue 34
17 extends along a top edge 35 of each of the skins 5 and 6.

18 Outer surfaces of the first side tongue 30 and the
19 second side tongue 32 extend flush with the first side edge
20 31 and the second side edge 33 respectively. The top tongue
21 34 is spaced inward from the top edge 35 of each of the
22 skins 5 and 6 so as to form a top lip or shoulder 38
23 extending outward from or above the top tongue 34. The
24 interior portion 39 of each skin 5 and 6 is of a relatively
25 thin and uniform thickness. For illustrative purposes, the

1 interior portion 43 of each skin 5 and 6 is approximately
2 0.085 inches thick. The first side, second side and top
3 tongues 30, 32 and 33 extend rearward from the inner surface
4 27 of the skins 5 and 6 approximately 0.54 inches and are
5 approximately 0.187 inches thick or at least twice as thick
6 as the interior portion 43 of the skins 5 and 6. The top
7 tongue 34 is spaced inward from the top edge 35
8 approximately 0.187 inches by top lip or shoulder 38 which
9 is approximately 0.250 inches thick.

10 The first side tongue 30 and the second side tongue 32
11 extend from the top edge 35 of each skin 5 and 6 to a bottom
12 edge 40 thereof. First and second ends 41 and 42 of the
13 third or top tongue 34 are spaced apart from the first and
14 second side tongues 30 and 32 respectively by first side and
15 second side channels 43 and 44.

16 Opposed skins 5 and 6 are connected together using two
17 side connectors 8 and 9 and top connector 10. The
18 connectors 8, 9 and 10 are of an identical H-shaped cross-
19 section and preferably formed from a single extrusion cut to
20 the desired lengths. The side connectors 8 and 9 are of
21 identical length, equal to the length of the first and
22 second tongue sections 30 and 32. The top connector 10 is
23 shorter than the side connectors 8 and 9 and slightly longer
24 than the top tongue 34, as discussed in more detail below.

1 Each of the connectors 8, 9 and 10 includes inner and
2 outer walls 55 and 56 connected together medially by cross-
3 member or web 57, so as to form first and second tongue
4 receiving grooves 58 and 59 extending longitudinally between
5 the inner and outer walls 55 and 56. The grooves 58 and 59
6 are sized to mate with the tongue sections 30, 32 and 34.
7 The width of the grooves 58 and 59 corresponds to the width
8 of the tongue sections 30, 32 and 34, which in the
9 embodiment as noted above is approximately 0.187 inches.
10 The outer wall 56 is approximately 0.187 inches thick which
11 is approximately at least as thick as most door hinge leaves
12 to permit portions of the outer wall 56 to be removed to
13 form a recess for receiving a hinge leaf without having to
14 cut into the skins 5 or 6 themselves. The inner wall 55 is
15 slightly narrower to conserve material.

16 The corners of the connectors 8, 9 and 10 which engage
17 portions of the tongues 30, 32 and 34 and the corresponding
18 corners of the tongues 30, 32 and 34 are radiused to provide
19 additional strength at the corners.

20 The skins 5 and 6 are connected together by first
21 placing connectors 8, 9 and 10 on first side tongue 30,
22 second side tongue 32 and top tongue 34 respectively of
23 first skin 5 such that the tongues 30, 32 and 34 extend into
24 the first tongue receiving grooves 58 of connectors 8, 9 and
25 10 respectively. Upper ends of side connectors 8 and 9

1 extend through the first and second side channels 43 and 44
2 respectively between the first side and second side tongues
3 30 and 32 and the top tongue 34 respectively. The channels
4 43 and 44 are slightly wider than the inner walls 55 of each
5 connector 8 and 9 to ensure that the upper ends of the
6 connectors 89 may pass therethrough without binding. The
7 top connector 10 is sized to completely span the distance
8 between interior surfaces of the inner walls 55 of the
9 connectors 8 and 9.

10 An adhesive is applied to the tongues 30, 32 and 34 or
11 within the first tongue receiving grooves 58 prior to
12 attachment of the connectors 8, 9 and 10 to tongues 30, 32
13 and 34. The frame 12 is then secured to the first skin 5.
14 In particular, the first and second stiles 13 and 14, top
15 rail 15 and bottom rail 16 are positioned against the inner
16 surface 27 of the first skin 5 such that the first and
17 second stiles 13 and 14 abut against the inner walls 55 of
18 side connectors 8 and 9 and top rail 15 abuts against the
19 inner wall 55 of top connector 10. An adhesive is applied
20 to the frame components to secure the stiles 13 and 14 and
21 top rail 15 to the skin 5 and connectors 8, 9 and 10
22 respectively and to secure the bottom rail 16 to skin 5.
23 The bottom rail 16 is generally positioned such that a
24 bottom edge 62 of the bottom rail 16 generally extends flush
25 with the bottom edge 40 of the skin 5. It is foreseen that

1 the frame 12 may be assembled prior to attachment to the
2 skin 5.

3 The rear skin 6 is then secured in place by inserting
4 first side, second side and top tongues 30, 32 and 34 of
5 skin 6 in the second tongue receiving grooves 59 of
6 connectors 9, 8 and 10 respectively. The tongues 30, 32 and
7 34 are secured within the second tongue receiving grooves 59
8 by gluing. The bottom rail 16 may also be glued to inner
9 surfaces 27 of the front and rear skins 5 and 6.

10 The skins 5 and 6, with the frame positioned therein,
11 are held together in a jig (not shown) and polyurethane foam
12 20 is injected into the interior space 19 between the skins
13 5 and 6 through a nozzle (not shown) inserted through a hole
14 65 in the bottom rail 16. After the foam 20 is injected
15 between the skins 5 and 6 a plug 66 is inserted into the
16 hole 65 and glued to the bottom rail 16 to seal off the hole
17 65.

18 A lock block 70 is formed on first stile 13 to provide
19 structure into which a hole for a knob may be bored and to
20 which a knob (not shown) may be secured. It is to be
21 understood that the second stile 14 is sufficiently thick,
22 to receive screws (not shown) for securing hinges (not
23 shown) thereto.

24 When the door assembly 1 is assembled, the outer walls
25 56 of side connectors 8 and 9 extend beyond the first and

1 second side edges 31 and 33 of the skins 5 and 6, while the
2 outer wall 56 of top connector 10 extends flush with the top
3 edge 35 of the skins 5 and 6. Portions of the outer walls
4 56 of the side connector 9 are typically cut away to form
5 recesses into which a leaf from a door hinge (not shown) may
6 be positioned. Portions of the outer walls 56 of the side
7 connectors 8 and 9 may be trimmed to ensure a proper fit of
8 the door assembly 1 within a door jamb. Similarly the
9 bottom rail 16 is adapted to permit trimming thereof to
10 ensure a proper fit of the door.

11 It is foreseen that the first side and second side
12 tongues 30 and 32 could also be spaced inward from the first
13 and second side edges 31 and 33 similar to the top tongue
14 34, such that the outer walls 56 of side connectors 8 and 9
15 extend flush with the first and second side edges 31 and 33
16 of the skins 5 and 6 when assembled.

17 The stiles 13 and 14 and top rail 15 can be formed from
18 thermoplastic material but are preferably formed from wood
19 which provides a desired rigidity for the assembled door.
20 Further, wood of the quality and type suitable for use in
21 forming the stiles 13 and 14 and top rail 15 is generally
22 readily available and relatively inexpensive. Further, door
23 assemblers are familiar with and have the tools necessary
24 for constructing and handling wooden frames 12. It is

1 foreseen that the frame components could also be formed from
2 thermoplastic material or other suitable materials.

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5 Thermoplastic Molding Materials

6 As noted above, the skins 5 and 6 are formed from a
7 composite molding material comprising a thermoplastic
8 material in combination with additives, reinforcing fibers
9 and/or fillers. A preferred composite molding material
10 comprises, by weight percent, 66-67% polypropylene copolymer
11 resin, 15% glass fiber strands 4mm (.16 inches) long and
12 .0035 mm (.00014 inches) in diameter, 15% talc, 1-2% UV
13 stabilizer(such as a benzotriazole)and 2-3% pigment. The
14 concentrations provided are approximations and it is to be
15 understood that a wide variety of concentrations may be
16 utilized. In particular, it is foreseen that the
17 concentration of polypropylene could range from
18 approximately 50% to approximately 100%. However, in most
19 applications a concentration of glass fibers of at least 10%
20 would be preferred along with additional additives, such
21 that the preferred range for the concentration of
22 polypropylene would range from 50% to 85%. It is foreseen
23 that the concentration of glass fibers would preferably
24 range from 10% to 20%.

1 Another composite thermoplastic material might comprise
2 approximately eighty percent(80%) by weight high impact
3 polystyrene with (20%) twenty percent by weight wood fiber.
4 Other thermoplastics which might be utilized include;
5 acrylonitrile-butadiene-styrene, acetal, nylon, polyester,
6 polypropylene, polyethylene, polyvinyl chloride and acrylic.

7 The talc is used as a filler and its ability to add
8 rigidity and stiffness and for thermal stability. Other
9 fillers which could be utilized include calcium carbonate
10 and cellulose such as the wood fiber noted above. Although
11 glass fibers are disclosed as the reinforcing fibers it is
12 foreseen that other fibers including carbon fibers could be
13 utilized. Similarly, a wide

14 The connectors 8, 9 and 10 are preferably also formed
15 from the composite molding material in an extrusion process.

16 In the preferred embodiment, the connectors 8, 9 and 10
17 are formed separate from the stiles 13 and 14 and top rail
18 15 respectively. However it is foreseen that the connectors
19 8, 9 and 10 could be integrally formed with the stiles 13
20 and 14 and the top rail 15 such that the stiles 13, 14 and
21 15 incorporate the connectors 8, 9 and 10 respectively.

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23 Method of Manufacturing Door Skins

24 The skins 5 and 6 are formed from the composite molding
25 material using a thermoplastic flow forming process. A

1 process diagram is shown in Figure 8. In the preferred
2 embodiment, the polypropylene is usually provided in pellet
3 form, the talc and the UV stabilizer as a powder and the
4 pigment in either pellet or powder form.

5 The original ingredients are fed in dry form into a
6 mixing hopper 101 mounted opposite the output end of an
7 extruder 104. The hopper 101 is of a type which weighs each
8 component independently, mixes the components and
9 gravimetrically feeds it into the extruder 104. The
10 extruder melts the composite thermoplastic material and
11 ejects the molten molding material into a sheet die 106.

12 Molten molding material flows out of the die 106
13 through an outlet 107 (not shown). Molten molding material
14 flows out of the outlet 107 into a first pair of lower or
15 first mold halves 111 and 112 as the lower mold halves 111
16 and 112 are advanced beneath the outlet 107 to the sheet die
17 106. The first pair of lower mold halves 111 and 112 are
18 supported in side by side relationship on a first trolley
19 113 which is moveably mounted on rails 115 and 116 which
20 extend transverse to the sheet die outlet 107. The outlet
21 107 is approximately as wide as the distance across the
22 first pair of lower mold halves 111 and 112. Each of the
23 lower mold halves 111 and 112 is shaped to form a first side
24 or face of a door skin, such as skins 5 or 6.

1 The molten molding material flows into the lower mold
2 halves 111 and 112 generally as a sheet as the mold halves
3 110 and 111 pass therebeneath on trolley 113. The size and
4 shape of the outlet 107 and the flowrate of molding material
5 through the die 106 is controlled by a computer control
6 system 118 such that the amount of molding material flowing
7 into a particular area of a lower mold half 111 or 112
8 generally corresponds to the amount of material necessary to
9 achieve the desired thickness of the molded part in that
10 area.

11 The lower mold halves 111 and 112 are then advanced on
12 the first trolley 13 into a first compression press 120 and
13 below a first pair of adjacently aligned upper mold halves
14 121 and 122 (not shown) already positioned in the
15 compression press 120. The upper mold halves 121 and 122
16 are then advanced into engagement with the lower mold halves
17 111 and 112 and the molding material is compressed
18 therebetween expelling any air trapped therebetween and
19 allowing the molten material to fill out and conform to the
20 shape of a molding cavity formed between the upper mold
21 halves 121 and 122 and the lower mold halves 111 and 112.

22 Cooling water, from a cooling system 124 is circulated
23 through or around the mold halves 111 and 112 and 121 and
24 122 to cool the molded part or door skin 125 formed
25 therebetween. Once sufficient time elapses to permit

1 adequate cooling, the mold halves 111 and 112 and 121 and
2 122 are separated in the compression press 120 and the door
3 skins are removed from between the upper mold halves 121 and
4 122 and the lower mold halves 111 and 112 by a vacuum
5 extraction tool 127.

6 A second pair of lower mold halves 131 and 132 are
7 secured on a second trolley 133 (not shown) which is
8 moveably mounted on rails 115 and 116. When the first
9 trolley 113 is in the first compression press 120, the
10 second trolley 133 is advanced beneath the sheet die 106 and
11 molten molding material flows through the outlet 107 thereof
12 into the second pair of lower mold halves 131 and 132. The
13 second trolley 133 beneath the sheet die 106 in a direction
14 opposite to which the first trolley 113 passes beneath the
15 die 106. After the second pair of lower mold halves 131 and
16 132 pass completely beneath the sheet die 106, they are
17 advanced on the second trolley 133 into a second compression
18 press 140 and beneath a second pair of adjacently aligned
19 upper mold halves 141 and 142 (not shown). The second
20 compression press 140 is positioned on a side of the sheet
21 die 106 opposite the first compression press 120. The
22 second pair of upper mold halves 141 and 142 are then
23 advanced into engagement with the second pair of lower mold
24 halves 131 and 132 and the molding material is compressed
25 therebetween expelling any air trapped therebetween and

1 allowing the molten material to fill out and conform to the
2 shape of a molding cavity formed between the upper mold
3 halves 141 and 142 and the lower mold halves 131 and 132.

4 Cooling water, from the cooling system 124, is
5 circulated through or around the mold halves 131 and 132 and
6 141 and 142 to cool the molded part or door skin 125 formed
7 therebetween. Once sufficient time elapses to permit
8 adequate cooling, the mold halves 131 and 132 and 141 and
9 142 are separated in the compression press 140 and the door
10 skins are removed from between the upper mold halves 141 and
11 142 and the lower mold halves 131 and 132 by a second vacuum
12 extraction tool 148.

13 As the second pair of upper and lower mold halves 141
14 and 142 and 131 and 132 are being compressed and separated
15 in the second compression press 140, the first trolley 113
16 is advanced out of the first compression press 120 past and
17 then back under the sheet die 106 toward the first
18 compression press 120 such that one pair of lower mold
19 halves 111 and 112 or 131 and 132 is being filled while the
20 other set is in the associated compression press 120 or 140.
21 The movement of the trolleys 113 and 133 is controlled by
22 the computer control system 118.

23 If the resulting door skin or molded part 125 is
24 flawed, the skin may be ground into relatively small pieces
25 which are fed back to the hopper 101 for reuse. Similarly,

1 any excess molding material purged or trimmed from between
2 the upper and lower mold halves may be ground and fed back
3 to the hopper 101 for reuse.

4 It is to be understood that while certain forms of the
5 present invention have been illustrated and described
6 herein, it is not to be limited to the specific forms or
7 arrangement of parts described and shown.